Recreational Vehicle Refueling Systems Test Strategy & Protocol

Reactive Organic Gas (ROG) emissions from RV refueling system = breathing loss + working loss

Breathing loss = vented emissions from the fuel tank during storage + permeation from the fillneck hose during storage + permeation from the fuel hose during storage (Fig. 1)

Working loss = displaced vapor from the receiving tank during refueling + dripping loss from the nozzle when stop the refueling (Fig. 2)

Permeation from the fillneck cap might be ignored if the cap is non-vented and made of low permeation plastic materials.

Vented emissions from the nozzle might be ignored if it is a non-dripping nozzle (sealed well).

Vented emissions from the pump might be ignored if it is a sealed steel pump.

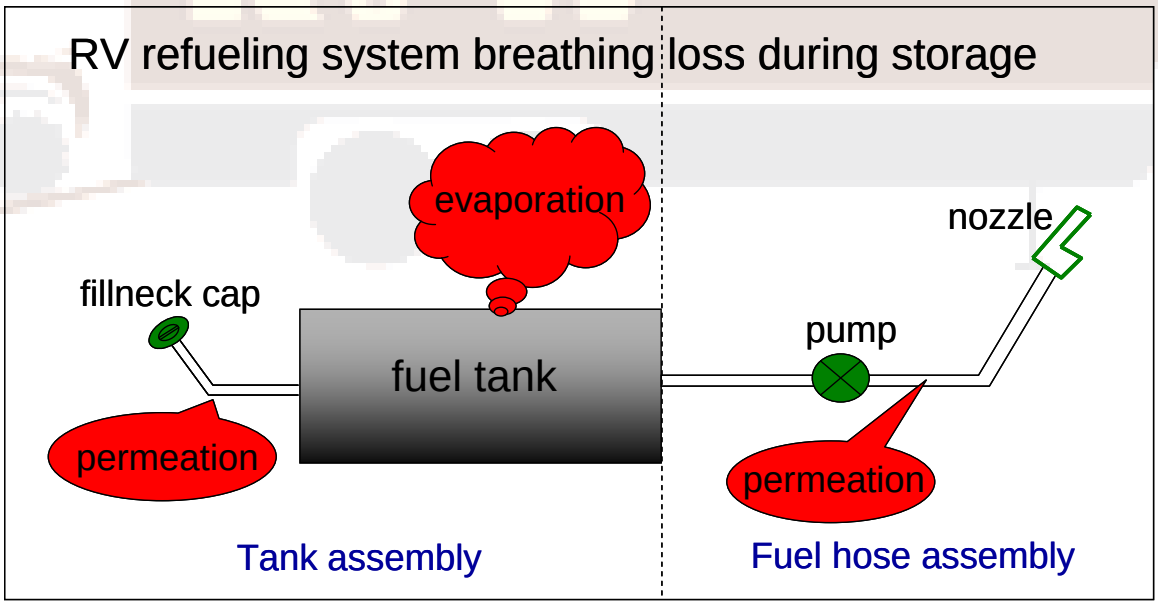

Figure 1. Schematic illustration of RV refueling system breathing loss during the storage.

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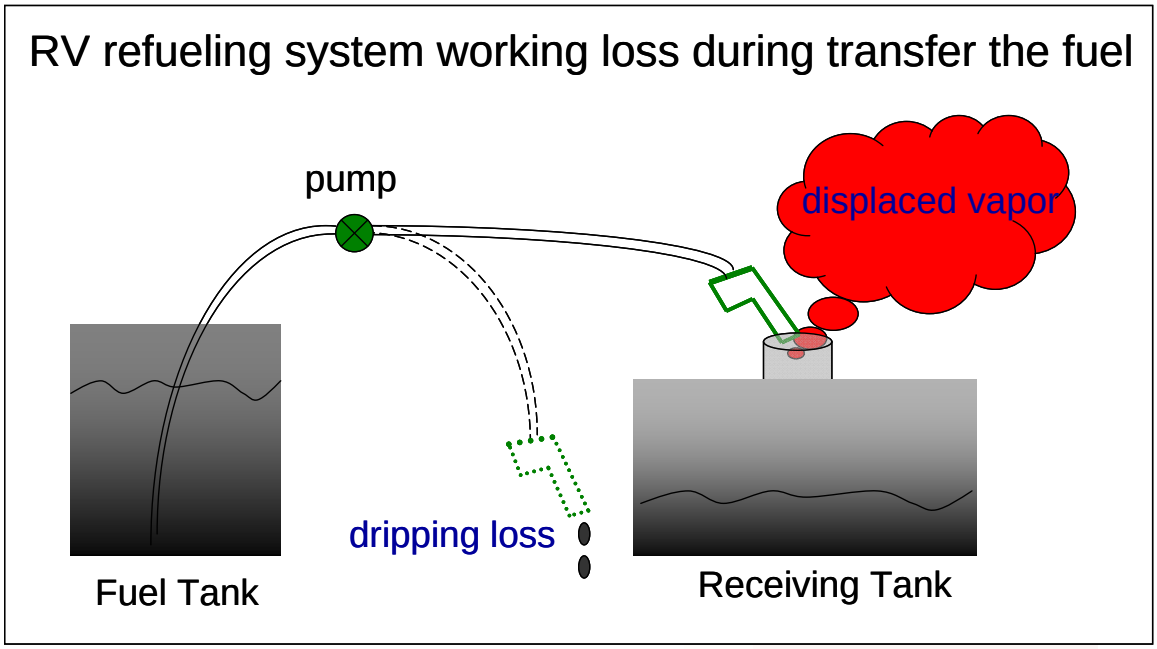

Figure 2. Schematic illustration of RV refueling system working loss during the refueling.

Displaced vapor measurement:

1. Deriving the formula to estimate refueling losses

To derive the formula for the mass of gasoline that will be displaced from the receiving tank when refueling from the fuel tank, the general vapor density formula[1] is used:

Wv = MvPv /RT

Where:

Wv = vapor density, lb/ft3

Mv = vapor molecular weight, lb/lb-mole;

Note: vapor molecular weight is related to RVP; so for gasoline with RVP 7 to 8.3, the molecular weight is 68 (AP-42, Table 7.1-3).

R = the ideal gas constant, 10.731 psia ft^3/lb-mole deg R

Pv = vapor pressure at daily average temperature, psia

T = daily average temperature, deg R

[1] From AP-42, page 7.1-64, and other references consulted

Note: this is absolute temperature in degrees Rankine (R), not Fahrenheit: to convert to deg R from deg F, add 459.69.

Since density (Wv) = m /V , m = VvMvPv /RT

Where:

m= mass of gasoline displaced as vapor (lb)

Vv = volume of gasoline displaced as vapor (ft3)

2. Calculating an estimated emission factor for displaced vapor:

Assumptions:

The volume of gasoline vapor displaced is equal to the volume of gasoline pumped out of the fuel tank into the receiving tank.

Gasoline RVP = 7

Vapor molecular weight = 68, at 60 deg. F. (see note above).

Conversions:[2]

1 gal gasoline =0.13 ft^3

T = 60 deg F = 519.69 deg R (absolute temp.)

1 lb = 453.59 grams

Plugging the values into above formula gives:

Mass of gasoline lost as vapor = VvMvPv /RT= 0.13 x 68 x 3.5 /10.731 x 519.69 = 0.005548 (lbs) = 2.52 grams

Therefore 1 gallon of gasoline pumped into a receiving tank results in 2.52 grams of gasoline lost as displaced vapor.

Emission factor for refueling losses (displaced vapor losses) = 2.52 gram/gal vapor (gasoline RVP 7, at 60 deg F).

Dripping loss measurement:

Dripping loss from the nozzle depends on the users how to terminate the refueling process. From ARB staff, about 1 ml gasoline drops from the nozzle when holding the

[2] Reference website: http://www.onlineconversion.com/volume.htm

nozzle in the fillneck of the receiving tank for a few seconds after refueling; about 30 ml liquid gasoline drops from the nozzle when pulling the nozzle out of the fillneck immediately after the refueling. With the volume of 1-30ml gasoline, ARB staff calculates the mass of the dripping loss: [3]

Mass of 1 ml CaRFG summer fuel E6: 0.71 grams

Mass of 30 ml CaRFG summer fuel E6: 21.8 grams

[3] Gasoline RVP 7: vapor molecular weight at 60 F M_V=68 lb/mole, Liquid density at 60 F W_L=5.6 lb/gal